Claims

[c1] What is claimed is:

1. A cantilever-type impeller that connects with a motor component to form a centrifugal fan motor for cooling portable electronic devices and other small devices, an impeller upper end corresponding to the impeller side of the fan motor and an impeller lower end corresponding to the motor-component side of the fan motor being defined along the impeller rotational axis, the impeller comprising:
a rotational force transmission portion provided on the impeller lower end, for receiving driving force from the motor component;
a lower endwall portion fixed in association with the rotational force transmission portion, for structuring a wall; and
an impeller blade unit having plural blades, each of the blades at its lower end being fixed outer-marginally to the upper surface of the lower endwall portion and each of the blades extending axially to its upper end, the blades together defining an opening at the impeller upper end, said impeller blade unit being dimensioned such that given that $2r$ represents the diameter to the outer circumference of the impeller blade unit and h represents the axial height of the impeller blade unit, the relationships $2r \leq h$ and $r \leq$ 12.5 mm are satisfied.

[c2] 2. A cantilever-type impeller according to claim 1, wherein the relationship $r \leq$ 5 mm is satisfied.

[c3] 3. A cantilever-type impeller according to claim 1, wherein at the

upper end opening of said impeller blade unit the blades at their inside corners are beveled at least partially in an arcuate contour.

[c4] 4. A cantilever type impeller according to claim 1, being at least partially made of a liquid crystal polymer, a carbon-fiber-reinforced liquid crystal polymer, a glass-fiber-reinforced liquid crystal polymer, a carbon-fiber and glass-fiber-reinforced liquid crystal polymer, soft iron, stainless steel, aluminum, or ceramic.

[c5] 5. A centrifugal fan motor for cooling portable electronic devices and other small devices, the fan motor including an impeller, and a motor component having a rotary section, a stationary section and a bearing, the bearing supporting the rotary section rotatably against the stationary section for rotation about the motor rotational axis, an impeller upper end corresponding to the impeller side of the fan motor and an impeller lower end corresponding to the motor-component side of the fan motor being defined along the motor rotational axis, said impeller connected with the rotary section and comprising:

a rotational force transmission portion provided on the impeller lower end, for receiving driving force from the motor component;

a lower endwall portion fixed correspondingly to said rotational force transmission portion, for structuring a wall; and

an impeller blade unit having plural blades, each of the blades at its lower end being fixed outer-marginally to the upper surface of the lower endwall portion and each of the blades extending axially to its upper end, the blades together defining an opening at the impeller

upper end, and rotation of said impeller blade unit therein generating an airflow streaming along the rotational axis through the opening and towards said lower endwall on its upper surface, said impeller blade unit being dimensioned such that wherein $2r$ represents the diameter to the outer circumference of the impeller blade unit and h represents the axial height of the impeller blade unit, the relationships $2r \leq h$ and $r \leq 12.5$ mm are satisfied.

[c6] 6. A centrifugal fan motor according to claim 5, wherein the relationship $r \leq 5$ mm is satisfied.

[c7] 7. A centrifugal fan motor according to claim 5, wherein the relationship $n \geq 5000$ rpm holds, n representing the motor rotational speed.

[c8] 8. A centrifugal fan motor according to claim 5, wherein the relationship $n \geq 10{,}000$ rpm holds, n representing motor rotational speed.

[c9] 9. A centrifugal fan motor according to claim 8, wherein said impeller is at least partially made of a liquid crystal polymer, a carbon-fiber-reinforced liquid crystal polymer, a glass-fiber-reinforced liquid crystal polymer, a carbon-fiber and glass-fiber-reinforced liquid crystal polymer, soft iron, stainless steel, aluminum, or ceramic.

[c10] 10. A centrifugal fan motor according to claim 9, wherein the total length of said motor component and said impeller along the rotational axis is less than 100 mm.

[c11] 11. A centrifugal fan motor according to claim 9, wherein the total length of said motor component and said impeller along the rotational axis is less than 70 mm.

[c12] 12. A centrifugal fan motor according to claim 9, wherein said bearing includes a pair of axially separated bearing units and the relationship $1.5 < h/m < 3.0$ holds, m representing the axial separation between said pair of bearing units.

[c13] 13. A centrifugal fan motor according to claim 9, wherein said bearing includes a pair of axially separated bearing units and the relationship $1.0 < h/m < 4.0$ holds, m representing the axial separation between said pair of bearing units.

[c14] 14. A centrifugal fan motor according to claim 9, wherein said bearing includes a pair of axially separated bearing units and the relationship $0.5 < h/m < 5.0$ holds, m representing the axial separation between said pair of bearing units.

[c15] 15. A centrifugal fan motor according to claim 9, wherein:
said bearing includes a pair of axially separated bearing units; and the stationary section of said motor component includes a stator having a core unit and coil windings and being disposed axially between said pair of the bearing units.

[c16] 16. A centrifugal fan motor according to claim 9, wherein the lower endwall portion along its undersurface on the motor-component side, together with a component being linked to said lower endwall portion,

is fixed directly to said bearing.

[c17] 17. A centrifugal fan motor according to claim 9, wherein the lower endwall portion along its undersurface on the motor component side, together with a component being linked to said lower endwall portion, is fixed to said bearing via a bearing holder.

[c18] 18. A centrifugal fan motor according to claim 9, further comprising a component linked to said lower endwall portion and directly fixed to said bearing.

[c19] 19. A centrifugal fan motor according to claim 9, further comprising a component linked to said lower endwall portion and fixed to said bearing via a bearing holder.

[c20] 20. A centrifugal fan motor according to claim 9, wherein the lower endwall portion and a portion of said impeller aligned therewith form an upper wall of said motor component.

[c21] 21. A centrifugal fan motor according to claim 9, wherein a portion of said impeller aligned with the lower endwall portion forms an upper wall of said motor component.

[c22] 22. A centrifugal fan motor according to claim 9, wherein:

said bearing includes a pair of bearing units, each bearing unit having an inner race and an outer race;

the stationary section of said motor component includes a shaft to which the inner races of said bearing are fixed; and

the rotary section of the motor component includes a rotor holder fixed to the outer races of the bearing.

[c23] 23. A centrifugal fan motor according to claim 9, wherein:

the rotary section of the motor component includes a rotor holder encompassing the rotary section; and

said rotational force transmission portion encloses and is fixed to the circumferential surface of said rotor holder.

[c24] 24. A centrifugal fan motor according to claim 9, wherein said rotational force transmission portion encloses at least part of the circumferential periphery of the rotary section.

[c25] 25. A centrifugal fan motor according to claim 9, wherein:

the rotary section of said motor component includes a rotor holder made of magnetic material;

a rotor magnet is fixed to the inner circumferential surface of said rotor holder; and

said rotational force transmission portion encloses at least part of the circumferential periphery of the rotary section.

[c26] 26. A centrifugal fan motor according to claim 9, wherein said bearing is formed by a slide bearing, and the relationship $1.5 < h/m < 3.0$ holds, m representing the bearing span axially.

[c27] 27. A centrifugal fan motor according to claim 9, wherein said bearing is formed by a fluid dynamic bearing, and the relationship $1.5 < h/m < 3.0$ holds, m representing the bearing span axially.

[c28] 28. A centrifugal fan motor according to claim 9, wherein said bearing is formed by a slide bearing, and the relationship $1.0 < h/m < 4.0$ holds, m representing the bearing span axially.

[c29] 29. A centrifugal fan motor according to claim 9, wherein said bearing is formed by a fluid dynamic bearing, and the relationship $1.0 < h/m < 4.0$ holds, m representing the bearing span axially.

[c30] 30. A centrifugal fan motor according to claim 9, wherein said bearing is formed by a slide bearing, and the relationship $0.5 < h/m < 5.0$ holds, m representing the bearing span axially.

[c31] 31. A centrifugal fan motor according to claim 9, wherein said bearing is formed by a fluid dynamic bearing, and the relationship $0.5 < h/m < 5.0$ holds, m representing the bearing span axially.

[c32] 32. A centrifugal fan motor according to claim 9, wherein:

said bearing is formed by a slide bearing; and

the stationary section of said motor component includes a stator having a core and coil windings both sides of said stator being located within the axial span of said bearing.

[c33] 33. A centrifugal fan motor according to claim 9, wherein:

said bearing is formed by a fluid dynamic bearing; and

the stationary section of said motor component includes a stator having a core and coil windings, both sides of said stator being located within the axial span of said bearing.

[c34] 34. A centrifugal fan motor according to claim 9, wherein at the upper end opening of said impeller blade unit the blades at their inside corners are beveled at least partially in an arcuate contour.

[c35] 35. A centrifugal fan motor according to claim 9, wherein:

the stationary section includes a stator having a core and coil windings; and

the rotary section includes

a shaft,

a shaft-retaining portion into which one end of said shaft is fixed, said shaft-retaining portion being formed integrally with, so as also to constitute, the lower endwall portion of said impeller,

a rotor holder fixed to an outer-marginal part of the shaft retaining portion either non-permanently or by means of an adhesive, crimping or welding, and

a rotor magnet fixed to and retained by an inner portion of the rotor holder, an inner portion of the rotor magnet radially opposing an outer portion of the stator across a small gap.

[c36] 36. A cantilever-type impeller that connects with a motor component to form a centrifugal fan motor for cooling portable electronic devices and other small devices, an impeller upper end corresponding to the impeller side of the fan motor and an impeller lower end corresponding to the motor-component side of the fan motor being defined along the impeller rotational axis, the impeller comprising:

a rotational force transmission portion provided on the impeller lower

end, for receiving driving force from the motor component;

a lower endwall portion fixed correspondingly to the rotational force transmission portion, the lower endwall portion therein configuring a wall surface; and

an impeller blade unit having plural blades, each of the blades at its lower end being fixed outer-marginally to the upper surface of the lower endwall portion and each of the blades extending axially to its upper end, the blades together defining an opening at the impeller upper end, and rotation of said impeller blade unit therein generating an airflow streaming along the rotational axis through the opening and towards said lower endwall on its upper surface, said impeller blade unit being dimensioned such that given that $2r$ represents the diameter to the outer circumference of the impeller blade unit, h represents the axial height of the impeller blade unit, and α represents a parameter, the relationships $2\pi rh = \alpha\pi r^2$, $4 \leq \alpha \leq 40$, and $r \leq 12.5$ mm are satisfied.

[c37] 37. A cantilever-type impeller according to claim 36, wherein the relationship $r \leq 5$ mm is satisfied.

[c38] 38. A cantilever-type impeller according to claim 36, wherein at the upper end opening of said impeller blade unit the blades at their inside corners are beveled at least partially in an arcuate contour.

[c39] 39. A cantilever type impeller according to claim 36, being at least partially made of a liquid crystal polymer, a carbon-fiber-reinforced liquid crystal polymer, a glass-fiber-reinforced liquid crystal polymer, a

carbon-fiber and glass-fiber-reinforced liquid crystal polymer, soft iron, stainless steel, aluminum, or ceramic.

[c40] 40. A centrifugal fan motor for cooling portable electronic devices and other small devices, the fan motor including an impeller, and a motor component having a rotary section, a stationary section and a bearing, the bearing supporting the rotary section rotatably against the stationary section for rotation about the motor rotational axis, an impeller upper end corresponding to the impeller side of the fan motor and an impeller lower end corresponding to the motor-component side of the fan motor being defined along the motor rotational axis, said impeller connected with the rotary section and comprising:

a rotational force transmission portion provided on the impeller lower end, for receiving driving force from the motor component;

a lower endwall portion fixed correspondingly to said rotational force transmission portion, for structuring a wall; and

an impeller blade unit having plural blades, each of the blades at its lower end being fixed outer-marginally to the upper surface of the lower endwall portion and each of the blades extending axially to its upper end, the blades together defining an opening at the impeller upper end, and rotation of said impeller blade unit therein generating an airflow streaming along the rotational axis through the opening and towards said lower endwall on its upper surface, said impeller blade unit being dimensioned such that given that $2r$ represents the diameter to the outer circumference of the impeller blade unit, h

represents the axial height of the impeller blade unit, and α represents a parameter, the relationships $2\pi rh = \alpha\pi r^2$, $4 \leq \alpha \leq 40$, and $r \leq 12.5$ mm are satisfied.

[c41] 41. A centrifugal fan motor according to claim 40, wherein the relationship $r \leq 5$ mm is satisfied.

[c42] 42. A centrifugal fan motor according to claim 40, wherein the relationship $n \geq 5000$ rpm holds, n representing the motor rotational speed.

[c43] 43. A centrifugal fan motor according to claim 40, wherein the relationship $n \geq 10{,}000$ rpm holds, n representing motor rotational speed.

[c44] 44. A centrifugal fan motor according to claim 43, wherein said impeller is at least partially made of a liquid crystal polymer, a carbon-fiber-reinforced liquid crystal polymer, a glass-fiber-reinforced liquid crystal polymer, a carbon-fiber and glass-fiber-reinforced liquid crystal polymer, soft iron, stainless steel, aluminum, or ceramic.

[c45] 45. A centrifugal fan motor according to claim 44, wherein the total length of said motor component and said impeller along the rotational axis is less than 100 mm.

[c46] 46. A centrifugal fan motor according to claim 44, wherein said bearing includes a pair of axially separated bearing units and the relationship $1.5 < h/m < 3.0$ holds, m representing the axial separation

between said pair of bearing units.

[c47] 47. A centrifugal fan motor according to claim 44, wherein said bearing includes a pair of axially separated bearing units and the relationship 1.0 $< h/m <$ 4.0 holds, *m* representing the axial separation between said pair of bearing units.

[c48] 48. A centrifugal fan motor according to claim 44, wherein said bearing includes a pair of axially separated bearing units and the relationship 0.5 $< h/m <$ 5.0 holds, *m* representing the axial separation between said pair of bearing units.

[c49] 49. A centrifugal fan motor according to claim 44, wherein:
said bearing includes a pair of axially separated bearing units; and the stationary section of said motor component includes a stator having a core unit and coil windings and being disposed axially between said pair of the bearing units.

[c50] 50. A centrifugal fan motor according to claim 44, wherein the lower endwall portion and a portion of said impeller aligned therewith form an upper wall of said motor component.

[c51] 51. A centrifugal fan motor according to claim 44, wherein a portion of said impeller aligned with the lower endwall portion forms an upper wall of said motor component.

[c52] 52. A centrifugal fan motor according to claim 44, wherein said rotational force transmission portion encloses and is fixed to the

circumferential surface of said rotor holder.

[c53] 53. A centrifugal fan motor according to claim 44, wherein said bearing is formed by a slide bearing, and the relationship $1.5 < h/m < 3.0$ holds, m representing the bearing span axially.

[c54] 54. A centrifugal fan motor according to claim 44, wherein said bearing is formed by a fluid dynamic bearing, and the relationship $1.5 < h/m < 3.0$ holds, m representing the bearing span axially.

[c55] 55. A centrifugal fan motor according to claim 44, wherein said bearing is formed by a slide bearing, and the relationship $1.0 < h/m < 4.0$ holds, m representing the bearing span axially.

[c56] 56. A centrifugal fan motor according to claim 44, wherein said bearing is formed by a fluid dynamic bearing, and the relationship $1.0 < h/m < 4.0$ holds, m representing the bearing span axially.

[c57] 57. A centrifugal fan motor according to claim 44, wherein said bearing is formed by a slide bearing, and the relationship $0.5 < h/m < 5.0$ holds, m representing the bearing span axially.

[c58] 58. A centrifugal fan motor according to claim 44, wherein said bearing is formed by a fluid dynamic bearing, and the relationship $0.5 < h/m < 5.0$ holds, m representing the bearing span axially.

[c59] 59. A centrifugal fan motor according to claim 44, wherein:
said bearing is formed by a slide bearing; and
the stationary section of said motor component includes a stator

having a core and coil windings, both sides of said stator being located within the axial span of said bearing.

[c60] 60. A centrifugal fan motor according to claim 44, wherein:
said bearing is formed by a fluid dynamic bearing; and
the stationary section of said motor component includes a stator having a core and coil windings, both sides of said stator being located within the axial span of said bearing.

[c61] 61. A cantilever-type impeller that connects with a motor component to form a centrifugal fan motor for cooling portable electronic devices and other small devices, an impeller upper end corresponding to the impeller side of the fan motor and an impeller lower end corresponding to the motor-component side of the fan motor being defined along the impeller rotational axis, the impeller comprising:
a rotational force transmission portion provided on the impeller lower end, for receiving driving force from the motor component;
a lower endwall portion fixed correspondingly to the rotational force transmission portion, the lower endwall portion therein configuring a wall surface; and
an impeller blade unit having plural blades, each of the blades at its lower end being fixed outer-marginally to the upper surface of the lower endwall portion and each of the blades extending axially to its upper end, the blades together defining an opening at the impeller upper end, and rotation of said impeller blade unit therein generating an airflow streaming along the rotational axis through the opening and

towards said lower endwall on its upper surface, said impeller blade unit being dimensioned such that given that $2r$ represents the diameter to the outer circumference of the impeller blade unit, h represents the axial height of the impeller blade unit, and α represents a parameter, the relationships $2\pi rh = \alpha\pi r^2$, $5 \leq \alpha \leq 35$, and $r \leq 12.5$ mm are satisfied.

[c62] 62. A cantilever type impeller according to claim 61, wherein at the upper end opening of said impeller blade unit the blades at their inside corners are beveled at least partially in an arcuate contour.

[c63] 63. A cantilever type impeller according to claim 61, being at least partially made of a liquid crystal polymer, a carbon-fiber-reinforced liquid crystal polymer, a glass-fiber-reinforced liquid crystal polymer, a carbon-fiber and glass-fiber-reinforced liquid crystal polymer, soft iron, stainless steel, aluminum, or ceramic.

[c64] 64. A cantilever-type impeller that connects with a motor component to form a centrifugal fan motor for cooling portable electronic devices and other small devices, an impeller upper end corresponding to the impeller side of the fan motor and an impeller lower end corresponding to the motor-component side of the fan motor being defined along the impeller rotational axis, the impeller comprising:
a rotational force transmission portion provided on the impeller lower end, for receiving driving force from the motor component;
a lower endwall portion fixed correspondingly to the rotational force transmission portion, the lower endwall portion therein configuring a

wall surface; and

an impeller blade unit having plural blades, each of the blades at its lower end being fixed outer-marginally to the upper surface of the lower endwall portion and each of the blades extending axially to its upper end, the blades together defining an opening at the impeller upper end, and rotation of said impeller blade unit therein generating an airflow streaming along the rotational axis through the opening and towards said lower endwall on its upper surface, said impeller blade unit being dimensioned such that given that $2r$ represents the diameter to the outer circumference of the impeller blade unit, h represents the axial height of the impeller blade unit, Z represents the number of blades in the impeller blade unit, d represents the thickness of the blade unit, and β represents a parameter, the relationships $2\pi r\varepsilon h=\beta\pi r^2$, $3\leq\beta\leq 30$, $2r\leq h$, and $r\leq 12.5$ mm, wherein $\varepsilon=(2\pi r-Zd)/2\pi r$, are satisfied.

[c65] 65. A cantilever type impeller according to claim 64, wherein at the upper end opening of said impeller blade unit the blades at their inside corners are beveled at least partially in an arcuate contour.

[c66] 66. A cantilever type impeller according to claim 64, being at least partially made of a liquid crystal polymer, a carbon-fiber-reinforced liquid crystal polymer, a glass-fiber-reinforced liquid crystal polymer, a carbon-fiber and glass-fiber-reinforced liquid crystal polymer, soft iron, stainless steel, aluminum, or ceramic.

[c67] 67. A centrifugal fan motor for cooling portable electronic devices and

other small devices, the fan motor including an impeller, and a motor component having a rotary section, a stationary section and a bearing, the bearing supporting the rotary section rotatably against the stationary section for rotation about the motor rotational axis, an impeller upper end corresponding to the impeller side of the fan motor and an impeller lower end corresponding to the motor-component side of the fan motor being defined along the motor rotational axis, said impeller connected with the rotary section and comprising:

a rotational force transmission portion provided on the impeller lower end, for receiving driving force from the motor component;

a lower endwall portion fixed correspondingly to said rotational force transmission portion, for structuring a wall; and

an impeller blade unit having plural blades, each of the blades at its lower end being fixed outer-marginally to the upper surface of the lower endwall portion and each of the blades extending axially to its upper end, the blades together defining an opening at the impeller upper end, and rotation of said impeller blade unit therein generating an airflow streaming along the rotational axis through the opening and towards said lower endwall on its upper surface, said impeller blade unit being dimensioned such that given that $2r$ represents the diameter to the outer circumference of the impeller blade unit, h represents the axial height of the impeller blade unit, Z represents the number of blades in the impeller blade unit, d represents the thickness of the blade unit, and β represents a parameter, the relationships $2\pi r\varepsilon h = \beta\pi r^2$, $3 \leq \beta \leq 30$, $2r \leq h$, and $r \leq 12.5$ mm, wherein $\varepsilon =$

$(2\pi r - Zd)/2\pi r$, are satisfied.

[c68] 68. A centrifugal fan motor according to claim 67, wherein the relationship $r \leq 5$ mm is satisfied.

[c69] 69. A centrifugal fan motor according to claim 67, wherein the relationship $n \geq 5000$ rpm holds, n representing the motor rotational speed.

[c70] 70. A centrifugal fan motor according to claim 67, wherein the relationship $n \geq 10{,}000$ rpm holds, n representing motor rotational speed.

[c71] 71. A centrifugal fan motor according to claim 70, wherein said impeller is at least partially made of a liquid crystal polymer, a carbon-fiber-reinforced liquid crystal polymer, a glass-fiber-reinforced liquid crystal polymer, a carbon-fiber and glass-fiber-reinforced liquid crystal polymer, soft iron, stainless steel, aluminum, or ceramic.

[c72] 72. A centrifugal fan motor according to claim 71, wherein the total length of said motor component and said impeller along the rotational axis is less than 100 mm.

[c73] 73. A centrifugal fan motor according to claim 71, wherein said bearing includes a pair of axially separated bearing units and the relationship $1.5 < h/m < 3.0$ holds, m representing the axial separation between said pair of bearing units.

[c74] 74. A centrifugal fan motor according to claim 71, wherein said

bearing includes a pair of axially separated bearing units and the relationship 1.0 $< h/m <$ 4.0 holds, m representing the axial separation between said pair of bearing units.

[c75] 75. A centrifugal fan motor according to claim 71, wherein said bearing includes a pair of axially separated bearing units and the relationship 0.5 $< h/m <$ 5.0 holds, m representing the axial separation between said pair of bearing units.

[c76] 76. A centrifugal fan motor according to claim 71, wherein:
said bearing includes a pair of axially separated bearing units; and the stationary section of said motor component includes a stator having a core unit and coil windings and being disposed axially between said pair of the bearing units.

[c77] 77. A centrifugal fan motor according to claim 71, wherein the lower endwall portion and a portion of said impeller aligned therewith form an upper wall of said motor component.

[c78] 78. A centrifugal fan motor according to claim 71, wherein a portion of said impeller aligned with the lower endwall portion forms an upper wall of said motor component.

[c79] 79. A centrifugal fan motor according to claim 71, wherein said rotational force transmission portion encloses at least part of the circumferential periphery of the rotary section.

[c80] 80. A centrifugal fan motor according to claim 71, wherein said

bearing is formed by a slide bearing, and the relationship $1.5 < h/m < 3.0$ holds, m representing the bearing span axially.

[c81] 81. A centrifugal fan motor according to claim 71, wherein said bearing is formed by a fluid dynamic bearing, and the relationship $1.5 < h/m < 3.0$ holds, m representing the bearing span axially.

[c82] 82. A centrifugal fan motor according to claim 71, wherein said bearing is formed by a slide bearing, and the relationship $1.0 < h/m < 4.0$ holds, m representing the bearing span axially.

[c83] 83. A centrifugal fan motor according to claim 71, wherein said bearing is formed by a fluid dynamic bearing, and the relationship $1.0 < h/m < 4.0$ holds, m representing the bearing span axially.

[c84] 84. A centrifugal fan motor according to claim 71, wherein said bearing is formed by a slide bearing, and the relationship $0.5 < h/m < 5.0$ holds, m representing the bearing span axially.

[c85] 85. A centrifugal fan motor according to claim 71, wherein said bearing is formed by a fluid dynamic bearing, and the relationship $0.5 < h/m < 5.0$ holds, m representing the bearing span axially.

[c86] 86. A centrifugal fan motor according to claim 71, wherein:
said bearing is formed by a slide bearing; and
the stationary section of said motor component includes a stator having a core and coil windings, both sides of said stator being located within the axial span of said bearing.

[c87] 87. A centrifugal fan motor according to claim 71, wherein:

said bearing is formed by a fluid dynamic bearing; and

the stationary section of said motor component includes a stator having a core and coil windings, both sides of said stator being located within the axial span of said bearing.